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Cave speleothems as repositories of microbial biosignatures

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The need to better understand the biodiversity, origins of life on Earth and on other planets, and the wide applications of the microbe-mineral interactions have led to a rapid expansion of interest in subsurface environments. Recently reported results indicated signs of an early wet Mars and rather recent volcanic activity which suggest that Mars's subsurface can house organic molecules or traces of microbial life, making the search for microbial life on Earth's subsurface even more compelling. Caves on Earth are windows into the subsurface that harbor a wide variety of mineral-utilizing microorganisms, which may contribute to the formation of biominerals and unusual microstructures recognized as biosignatures. These environments contain a wide variety of redox interfaces and stable physicochemical conditions, which enhance secondary mineral precipitation and microbial growth under limited organic nutrient inputs. Enigmatic microorganisms and unusual mineral features have been found associated with secondary mineral deposits or speleothems in limestone caves and lava tubes. In this study, Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive X-ray spectroscopy (EDS) analyses were conducted on cave speleothem samples to assess microbe-mineral interactions, evaluate biogenicity, as well as to describe unusual mineral formations and microbial features. Microbial mats, extracellular polymeric substances, tubular empty sheaths, mineralized cells, filamentous fabrics, as well as "cell-sized" etch pits or microborings produced by bacterial cells were observed on minerals. These features evidence microbe-mineral interactions and may represent mineralogical signatures of life. We can thus consider that caves on Earth are plausible repositories of terrestrial biosignatures where we can look for microbial signatures.
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